DESIGN OF A USSD SYSTEM FOR TB CONTACT TRACING

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ABSTRACT

Tuberculosis (TB) is a communicable disease spread by tiny airborne particles that are expelled when a person with the disease coughs or sneezes. Botswana has had one of the highest TB notification rates in the world since 2000, mainly as a result of increasing rate of HIV prevalence in the country. People at a high risk of contracting TB are close contacts to a person who already has the disease. It is therefore important that after being diagnosed with TB, all close contacts of the affected patient are traced and interviewed to decide whether they need to be tested for the disease or not, so as to combat the spread of TB. This paper explores the issues involved in the design of a mobile phone-based application for TB contact tracing in Botswana. Problems with the current paper-based method are discussed, and a design and architecture of a mobile phone-based Unstructured Supplementary Service Data (USSD) platform is presented.

KEY WORDS

TB, contact tracing, USSD, mobile phone, health.

1. Introduction

Botswana is grappling with high prevalence of infectious diseases like Tuberculosis (TB), Malaria, HIV/AIDS and other Sexually Transmitted Infections (STIs). In particular, Botswana has had one of the highest TB notification rates in the world since 2000, mainly as a result of the increasing rate of HIV prevalence in the country [2]. In low resource settings like in Botswana, patient treatment and adherence monitoring are a challenge. According to the World Health Organization (WHO) [14], the National TB Program in Botswana is falling short of reaching its objectives in combating TB. The report points out that this is partly caused by inadequate human resources, low surveillance and monitoring of TB patients and their contacts, and deficiencies in coordinating data collection and reporting. As a consequence of all or some of these short comings, TB rates have increased recently [2]. Problems with management and analysis of patient data records create problems with monitoring and counteracting the effects of these diseases on the socio-economic landscape of the country. TB patient and contact tracing, treatment adherence monitoring and remote data collection are areas that need particular attention in the fight against the spread of TB.

In note of such problems, the Ministry of Health (MoH) and Botswana UPenn Partnership (BUP) proposed an implementation of a TB Contact Tracing system (TBCT) using Unstructured Supplementary Service Data (USSD). This system will be designed to take advantage of high mobile phone availability usage in the country to improve data collection and reduce costs of manual data collection. The MoH has also taken several steps in the field of Health Informatics to centralise and improve data collection, patient and information management. The proposed TBCT system will therefore need to integrate with any existing MoH systems.

This paper focuses on the design of a USSD system which will be used for collection of data from TB patients to facilitate contact tracing. The system will also support in decision making on which patients should visit a health centre to be tested for TB, as well as in providing relevant reports and statistics to help improve decision making by health personnel.

This paper is arranged as follows: first the current method of TB contact tracing in Botswana and its problems are discussed; the background of USSD and mobile phone systems is discussed next; then the aims and hypotheses are stated. Next the proposed solution is presented; the system architecture is discussed next and finally the conclusion.

2. TB Contact Tracing In Botswana

The current process of TB contact tracing in Botswana is depicted in Figure 1 below. When a person is diagnosed with TB, they have to fill a contact examination form detailing people that they have had close contact with. A contact, according to [11], is “a person living with or having close daily or weekly contact for greater than four hours at a time with the TB patient”. Contacts might include for example, family members, prolonged contacts and co-workers, and particular attention is paid to children under five and HIV-positive individuals.

A health worker will then go out into the community to locate and screen the contact. Contact screening entails asking each contact a set of questions to determine if they have symptoms of TB. The responses are recorded in the
contact examination form. This investigation is required to start within three working days from the date of registration of the TB patient to identify infected contacts [2].

Figure 1. TB Contact Tracing Process Model

The contact evaluation entails asking the contacts a set of questions. Based on the answers given by the contact, they may be referred to the nearest health facility for a TB test. The names of these tuberculosis suspects found are to be entered into the "Suspect and Sputum Dispatch Register", until confirmed. Close contacts of MDR (Multidrug-resistant) -TB patients have been known to have high rates of MDR-TB, and should be followed up for at least two years [2].

The most common method of searching for and finding TB patients in Botswana is through contact investigation. Current common methods of data collection and patient management are manual and paper-based. The current system has several disadvantages:

a) Shortage of health personnel - The government of Botswana is trimming its wage bill by 5% for the next 3 years to try and align with the International Monetary Fund (IMF) recommendations. In addition to this measure, the government has also advocated that there be no new job creations in government in the next 3 years [7]. Increasing health worker numbers therefore seems a distant dream. The inadequate health care workers are themselves overwhelmed by other core responsibilities.

b) Time and travel costs - Botswana is a sparsely populated country. The Population density (people per sq. km) in Botswana was last reported at 3.54 in 2010, according to the World Bank [12]. This means the already limited health care workers have to travel long distances from their base locations to monitor TB contacts. Travel is expensive and time-consuming.

c) Poor data records and distribution- Once the health care workers locate the close contacts,
they interview them; screen them for TB, and all the information about the contact is captured into paper documents. The paper documents are brought back to the health facility and transferred into a database by data clerks [2]. This has resulted in poor data records since records sometimes go missing. Also the information is not centralized, meaning that it can only be accessed from one location.

d) Analysis of data - Since the system is paper-based with poor records and not centralized, it is very difficult to analyse the data for decision-making and report-creation. Also decision making is made by the TB focal person, making it prone to human error.

The proposed system will help solve these problems by allowing data collection to a central data store through mobile phone interaction without involving a TB focal person. With data submitted in real time to a central point, decision-making and production of reports can be instant and more effective.

3. Background

3.1 Mobile Phones and USSD

Mobile network coverage and mobile ownership and accessibility are very high in Botswana. Botswana has a mobile cellular subscription of 150 per 100 people [13]. USSD is a Global System for Mobile Communications (GSM) communication technology similar to SMS that is used to send messages between a mobile phone and an application server in the network [1]. GSM is an open technology for transmitting mobile voice and data services [6]. For this project, USSD was selected instead of SMS because of the following reasons:

a) Unlike SMS which is a store-and-forward, transaction-oriented technology [3], USSD is session-based and interactive, and is real-time, therefore offering faster response [1, 3]. USSD service is almost seven times faster than SMS, and there is minimal delay between sending a query and receiving a response [4, 8].

b) Being a session-based protocol it allows for a real-time “session” to be initiated between a mobile user and an application platform to send data back and forth.

c) USSD sessions can be initiated by the user (pull) or the application (push). Being interactive means menu-based applications can be supported [3].

d) USSD includes the ability to work when users are roaming (virtual home environment concept) as USSD commands are routed back to the home mobile network’s Home Location Register (HLR), the ability to work on all existing GSM mobile phones and support by both SIM Application Toolkit and the Wireless Application Protocol (WAP) [3]. When roaming in another place or country there are no charges on roaming partners like for SMS [4].

e) It is also much cheaper than SMS and uses simple operations [4]. Also the user does not need to remember anything and does not need either an Internet connection or to install any applications [4, 8].

USSD is mostly familiar to users through the concept of recharging prepaid handsets, “call me backs”, balance requests and showing balance after calling. It is also increasingly being adopted for interactive applications like mobile chat, roaming with prepaid service, simultaneous software upgrading of huge customer base and mobile banking [4].

3.2 Health Systems and USSD

In Health systems USSD has been used before for systems such as those for patient monitoring.

Wouters et al [5] implemented a prototype patient monitoring system for transmitting information from home-based care workers to health facilities using USSD. Care givers giving basic nursing care to people in their own homes initially compiled reports based on daily and weekly visits to patients and only discussed them with sisters in workshops organized between 1 and 4 times a month. Time pressure and long walking distances caused delays in sisters and care givers interacting, therefore patients could not be monitored frequently and sisters could not act as quickly as desired to help and save patients’ lives. The USSD system therefore allows care workers to measure vital signs and submit the information via USSD, which is available to the sister via a website.

4. Hypothesis

The aim of the research is to

1. Develop a mobile phone-based USSD system for TB contact tracing in Botswana.

2. Pilot test the implemented system in conjunction with the MoH and BUP with participants in identified regions (Bobirwa and Mahalapye sub-districts) which have recorded a high number of TB patients in recent years [11].

Hypothesis 1: The mobile phone-based USSD system will screen more contacts in a shorter time than the currently used method.
**Hypothesis 2:** The mobile phone-based USSD system will have lower contact screening costs than the currently used method.

The result of the pilot test will inform further research in the areas of acceptance and adoption of mobile phone-based systems use in data collection and monitoring of contacts.

5. **Proposed Solution**

Many Batswana are familiar with mobile phone banking and other more complex uses of their phones. Therefore, a mobile phone-based intervention to improve screening and adherence rates would likely find a receptive audience in Botswana [11].

The system will have a mobile-phone based interface on the side of the TB contacts and a web interface on the side of health workers. The system will collect data through interacting with a TB contact. The data will be stored in a centralized database. Once the data is collected the system will help decide whether or not to refer the contact for a TB test. The system will initiate a session with the user, during which it presents some questions to screen the user for TB. Depending on the answers to these questions (whether they show potential TB symptoms or not, or if they are at risk for contracting the disease), the user may be referred to a local clinic for a TB test. The system will also assist health workers in doing follow ups with referred contacts in case they do not respond in a given timeframe, to evaluate whether they indeed went for a test and whether they have TB or not. A web application front-end will be provided to allow the health workers to access the stored information and create and view reports. A user survey and requirements analysis will define the services to be provided in this interface.

6. **System Architecture**

The envisioned systems will have multiple interfaces to work with different devices and users. The mobile phones will interact with the system through the GSM networks. The standard mobile phones will use the USSD protocol to communicate with the system. The messages are sent to the USSD gateway through this network, which will pass them on to the server. These are the devices that the TB contacts will use.
The health workers will have access to the system through some smartphone application or the general PCs which will have web applications to manage the data and its analysis. The USSD gateway will be used to interface the applications and database server with the GSM mobile devices.

On the side of the health worker the system will require secure login for data confidentiality. It will also be behind a firewall in order to allow filtered access to the system because of the sensitive nature of the data. The system will run on an encrypted file system on the server to prevent unauthorised access to files on the hard drive.

Through the use of the USSD gateway, the system will enable contacts to interact, receive and respond to the screening questions. After all answers have been provided, the system, through an application at the server, will determine whether the contact needs to undergo testing.

7. Conclusion

This paper has presented the design of a mobile-phone-based USSD system that will be used for TB contract in Botswana. The aspects of the system have been investigated and explained. The next stage is the implementation of the system and deployment on mobile networks before pilot testing. For internal testing, a USSD simulator will be used. The success of the system hinges on acceptance by all stakeholders, especially healthcare workers and TB patients and their contacts; hence an elaborate user acceptance testing plan will be designed and carried out. We envisage the system to evolve to cater for cases where a patient or a contact having accepted involvement in the system does not respond to USSD session request from the system.

References


